

SPAWNING OF THE ANCHOVY, *ENGRAULIS ENCRASICOLUS* (L.), IN THE NORTHERN ADRIATIC SEA IN 1989, THE YEAR OF INTENSIVE BLOOMS

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ABSTRACT

The main spawning area of the Adriatic anchovy (*Engraulis encrasicolus*) is the shallow Northern Adriatic. In 1989, an unusually low anchovy egg production, a considerable mortality of larvae, and an unusual location of spawning centers in the limited areas were recorded in the Northern Adriatic. Since the major part of the Northern Adriatic was covered by the phytoplankton and benthic diatoms blooms, gelatinous aggregates and "marine snow" during the peak of the spawning season, it is speculated that they caused the observed anomalies in the reproduction of this fish.

Key words: anchovy, spawning, Northern Adriatic, blooms

Ključne besede: inčun, drstenje, Severni Jadran, cvetenje

INTRODUCTION

Long-term estimates of the anchovy, *Engraulis encrasicolus*, biomass in the Adriatic showed a continuous decrease since 1978 (Regner *et al.*, 1985; Dulčić, 1993; Dulčić & Cetinić, 1993). The anchovy stock almost collapsed during the years 1986-1989. Since the sardine stock increased in the same period (Vučetić & Alegria-Hernandez, 1987), this phenomenon could not be attributed to overfishing. During the same period, excessive summer blooms of phytoplankton and benthic diatoms became regular events in the Adriatic Sea. The surface affected by the blooms (Marchetti *et al.*, 1988; Todini & Bizzari, 1988; Filipič, 1990; Deggobis *et al.*, 1991), large quantities of gelatinous (mucilaginous) material (Deggobis *et al.*, 1991; Rinaldi *et al.*, 1990; Cabrini *et al.*, 1992; Deggobis *et al.*, 1995) and "marine snow" (including flocks, strings and small clouds) (Fonda-Umani *et al.*, 1989; Fanuko & Turk, 1990; Deggobis *et al.*, 1991; Deggobis *et al.*, 1995) was increasing from year to year, particularly in the shallow Northern Adriatic and along the Italian coast up to the peninsula of Gargano, corresponding precisely to the spawning season and the main reproductive areas of the anchovy.

The severe bloom events began to decrease in 1990. Since these two phenomena coincided both spatially and temporally, the spawning of the anchovy in the Northern Adriatic during the 1989 spawning season was analyzed in order to determine whether a connection between the blooms and anchovy reproduction exists.

MATERIAL AND METHODS

Plankton material was collected at 14 stations in the Northern Adriatic during R/V three cruises carried out in June 13-14, July 6-7 and July 24-25 (R/V "Vila Velebita", Nansen plankton net, diameter 80 cm, vertical tow 0.5 m/s), and at 20 stations in August 15-18 (R/V "Vila Velebita" and "Bios", Nansen net and Bongo-20 plankton net, two cylinders of 20 cm diameter, oblique tow, 1.5 to 2 knots). Both nets were of 250 µm meshes. At each station, data on temperature and salinity from the surface to the bottom were collected by CTD probe at 1 m intervals.

The anchovy planktonic stages were separated from the samples, eggs were classified into five developmental stages, yolk-sac larvae into three length groups, and larvae into length groups of 2 mm. Instantaneous mor-

tality rates of eggs, yolk-sac larvae and larvae were estimated, and the quantity of anchovy eggs was expressed as the number of eggs produced per $1\text{m}^2/\text{day}$. For details on egg production estimates see Regner (1985), Regner *et al.* (1985), as well as Piccinetti *et al.* (1982); Regner & Dulčić (1990) provide estimates for mortality of larval stages.

RESULTS

Intensive algal blooms, gelatinous aggregates and "marine snow" were recorded in Northern Adriatic in June-August 1989. In June the blooms were limited to the coastal waters along the Italian coast, while in July and August they spread over all the Northern Adriatic, with the exception of a 10-15 mile wide zone along the west Istrian coast. This zone was under the influence of the geostrophic current which brings the Mediterranean water of lower temperatures and higher salinity through the Central and Southern Adriatic. The surface of all the other areas of Northern Adriatic was covered with dense patches of mucous matter released by pelagic diatoms; echo sounders showed that these patches were dense and randomly distributed from the bottom to the sea surface.

The estimates of mean daily production of anchovy eggs over the surveyed area was considerably low in all the surveys (Table 1).

Month	No. eggs/ m^2/day	95% confidence limit	
		lower	upper
June	2.5	1.79	3.21
July (early)	1.5	1.09	1.91
July (late)	5.5	3.73	19.3
August	47.6	32.91	99.91

Table 1: The estimates of mean daily production of anchovy eggs in the Northern Adriatic (1989).

Tabela 1: Ocenjene srednje vrednosti dnevne produkcije inčunovih iker v severnem Jadranu (1989).

As far as the spatial distribution is concerned, in June, when the blooming was not yet widespread, two centers of spawning, although of very low intensity of only 3 eggs/ m^2/day , were observed. One was situated in the northwestern part of the surveyed area, in the waters influenced by the river Po inflow, while the other one was found about 6 miles off the Istrian coast (Fig. 1). In July, during the heavy blooms, spawning areas of the same intensity were found along the Istrian coast (Fig. 2). In August, one center of relative intensive spawning (100 or more eggs/ m^2/day) was found in an area 10 to 20 miles off the Istrian coast (Fig. 3). This center was situated at the edge of the frontal zone where Northern

Adriatic waters and the geostrophic current collide.

This indicates that anchovy could not spawn in eutrophic waters of central and western parts of Northern Adriatic, which are their traditional spawning areas, probably because these parts were under the strong influence of blooms. They were apparently forced to spawn either in the narrow and relatively oligotrophic zone along the coast of Istrian peninsula, or in the frontal zone where the water was still relatively "clean".

The instantaneous mortality rates of anchovy planktonic stages were estimated (Table 2).

Stage	Mortality rate	Standard error	F	P<
Eggs and yolk-sac larvae	-0.4849	0.0228	452.16	0.001
Larvae	-0.5181	0.1393	13.83	0.1

Table 2. The instantaneous mortality rates of anchovy planktonic stages in Northern Adriatic (1989).

Tabela 2: Hipne stopnje mortalitete planktonskih stadijev inčuna v severnem Jadranu (1989).

It should be emphasized that for the first time since mortality of anchovy planktonic stages has been studied (20 years), the mortality rate of larvae was higher than that of eggs and yolk-sac larvae. At the same time, the fact that no larvae older than 12 days (7 days after the complete yolk-sac resorption) have been found (Fig. 4) indicates that conditions for their survival were unusually unfavourable in the Northern Adriatic during the 1989 spawning season.

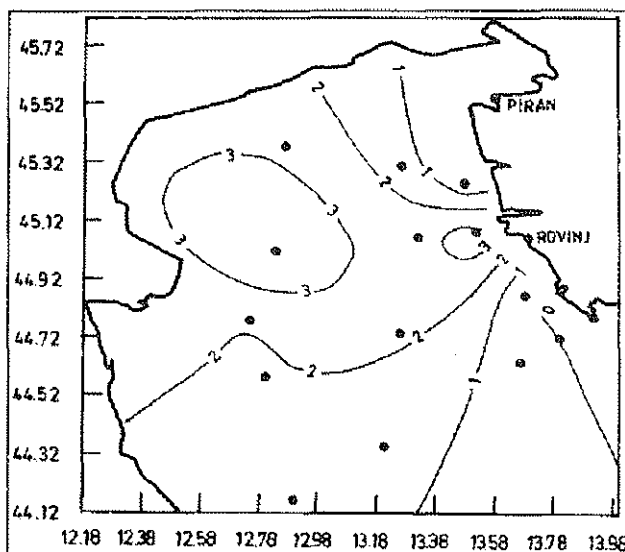


Fig. 1: Anchovy egg distribution ($\text{N}/\text{m}^2/\text{day}$) on June 13-14, 1989.

Slika 1: Razširjenost inčunovih jajc ($\text{N}/\text{m}^2/\text{dan}$) 13. in 14. junija 1989.

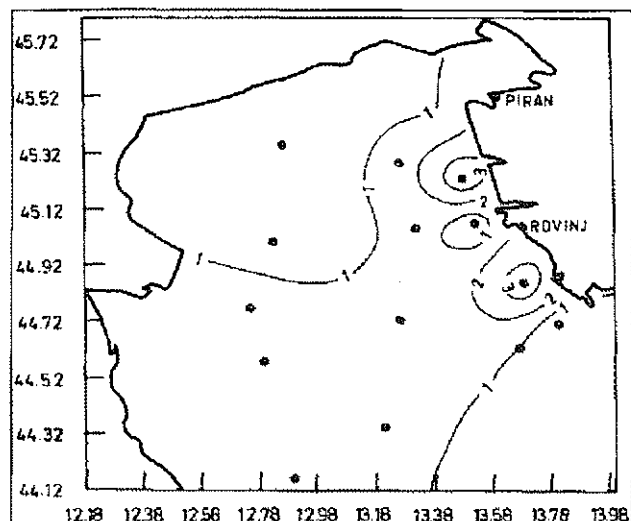


Fig. 2: Anchovy egg distribution (N/m/day) on July 24-25, 1989.

Slika 2: Razširjenost inčunovih jajc (N/m/dan) 24. in 25. junija 1989.

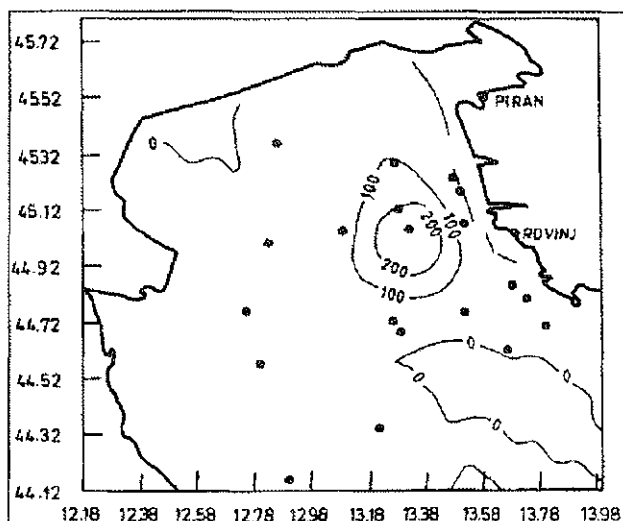


Fig. 3: Anchovy egg distribution (N/m/day) in August 15-18, 1989.

Slika 3: Razširjenost inčunovih jajc (N/m/dan) od 15. do 18. avgusta 1989.

DISCUSSION

The anchovy egg production during the investigated period from June to August 1989 was the lowest ever recorded in the Northern Adriatic (Varangolo, 1967; Štirn, 1969; Piccinetti *et al.*, 1982; Regner *et al.*, 1985). The spatial distribution of the spawning centers, particularly during the months (second part of June, July) of the most intensive bloom (Deggobis, 1989; Deggobis *et al.*, 1995), indicates that the anchovy could not spawn in its main spawning area which, according to the above mentioned authors, is normally situated in the eutrophic waters of the central and western part of the Northern Adriatic. Rather, the fish were apparently forced to spawn in the limited areas of relatively "clean" waters, where the environmental conditions for its reproduction were less suitable. At the same time, the mortality rate of anchovy larvae was found to be considerably higher than the previously estimated rate in the same area and with the same methods applied (Piccinetti *et al.*, 1982). This event, together with the lack of older larvae in all the samples collected, indicates that not only the conditions for spawning, but also the conditions affecting larval survival were unfavourable during the period of blooms.

Since there is no direct evidence on the interrelationship between anchovy spawning and the blooms, no clear explanation can currently be given on how the blooms might affect anchovy reproduction. One hypothesis is that they change the chemical properties of the water as well as the quantitative composition of the plankton, which would in turn affect the trophic status of both adult fish and larvae. The blooms may perhaps even physically irritate the adult fish, while the patches of mucous matter can act as a trap for yolk-sac larvae and

larvae. As a matter of fact, several yolk-sac larvae and larvae collected with the plankton nets had obviously died prior to capture: they were clearly decomposed and enveloped in the mucous matter. Most probably all these factors act simultaneously.

Since the regions covered by excessive blooms gradually spread during a long period of years, particularly over the principal spawning areas of the anchovy, it can be supposed that anchovy reproduction was seri-

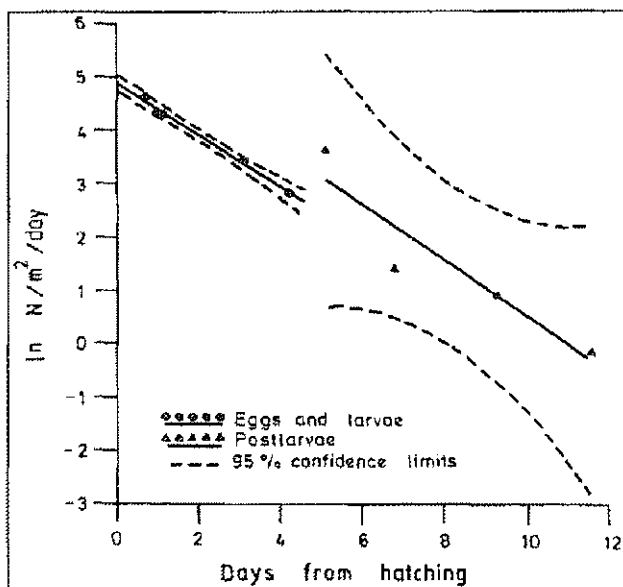


Fig. 4: Estimated mortality rates of anchovy planktonic stages.

Slika 4: Ocenjena mortaliteta planktonskih stadijev inčuna.

ously disturbed during this period due to gradual reduction of their reproduction areas. Finally, when the blooms reached their maximum, the fish were forced to reproduce in the limited areas of relatively clean waters

where they usually do not spawn intensively. Therefore, blooms, gelatinous aggregates and "marine snow" are potentially one of the main factors responsible for the decrease of the anchovy stock in the Adriatic.

POVZETEK

Glavno dristišče jadranskega inčuna *Engraulis encrasicolus* je plitvi severni del Jadranskega morja. Leta 1989 tu ni bila ugotovljena le nenavadno nizka produkcija inčunovih iker, pač pa tudi precejšnja mortaliteta larv in nenavadna lokacija dristišvenih središč v omejenih območjih tega dela Jadrana. Upošteva je dejstvo, da je bil severni Jadran na vrhuncu dristišvenega obdobja poln cvetočega fitoplanktona in bentonskih diatomej (kremenastih alg), želatinastih agregatov in "morskega snega", bi lahko sklepali, da so prav ti dejavniki povzročili opažene anomalije v reprodukciji jadranskega inčuna.

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